P-ISSN: 2528-5688
E-ISSN: 2528-5696

VOLT

Jurnal Ilmiah Pendidikan Teknik Elektro

Journal homepage: jurnal.untirta.ac.id/index.php/VOLT

Vol. 3, No. 2, Oktober 2018, 78 – 84

IMPLEMENTATION OF THE SUN TRACKER SYSTEM WITH FUZZY LOGIC ON SOLAR PANELS

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DOI: 10.30870/volt.v3i2.3578

Received: July, 4th 2018. *Received in revised form*: August, 28th 2018. *Accepted*: September, 29th 2018.
Available online: October, 30th 2018

Abstract

To get the optimal solar energy, we need a system that can keep the Sun Tracker solar panel is always perpendicular to the direction of sunlight. Solar Tracker systems using Fuzzy logic implemented using Field-Programmable Gate Array to control the movement of the frame of the solar panel with feedback to suit the direction of arrival of the Sun. Four smaller solar cells are used as sensors for controlling DC motor which is connected to the frame of the solar panels. From this study indicated that the solar panels generate greater energy by using solar Tracker systems 2.062% greater than the solar panels without a tracker.

Keywords: field-programmable gate array, fuzzy logic, motor dc, sun tracker, solar cell

INTRODUCTION

Along with the increase of population and technological advances lead to electrical energy needs in Indonesia. Currently the source of energy used to meet the needs of electricity using only the wind and water aid. Other energy sources that could be used is the solar energy. Solar energy can be harnessed in a way change sunlight into electrical energy. A tool that can be used is the solar cell.

In General, the solar cell is a smorgasbord of semiconductors that can absorb a photon of sunlight and convert it into electricity. Each kind of different semiconductors can only absorb photons at a particular energy level are known as the bandgap. Solar cells solar energy as a Catcher then arranged parallel with the Sun Tracker System. Electric energy produced solar cells will be a maximum when the Sun Tracker is always perpendicular to the direction of the oncoming sunlight. In other words, the solar cell should follow the direction of the movement of the Sun's light.

The difficulties that arise in order to maximize the absorption of sunlight intensity is in the formation of the perpendicular angle between the solar cells with the direction of the oncoming sunlight. Therefore, it needed a system that could control the solar cells automatically to keep focus on the direction of arrival of the Sun. Some previous research used a microcontroller to control solar tracking system (Fachri, Sara, & Away, 2015; Resi, 2013; Saputra, 2008).

METHOD

Block diagram of the solar Tracker System shown in Figure 1. The system consists of a 200-XuLA Board using FPGA Xilinx Spartan 3 family XC3S200A that are coded to use VHDL to run the fuzzification and defuzzification logic algorithm (Vandenbout, 2012). This block will receive input from the sensor solar panels connected to the ADC in microcontroller 8535. Next the FPGA will give output to the microcontroller to generate PWM signals as the driving motor DC motor DC X and Y which is connected to the main solar panel frame

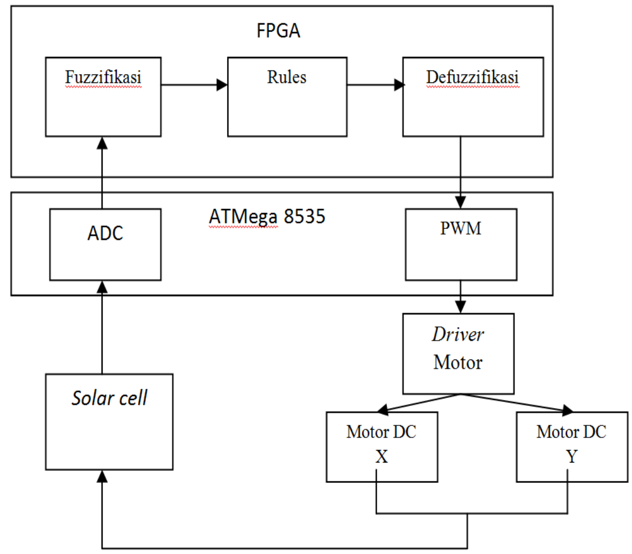

Figure1. Block Diagram of The System

In order to work in accordance with the draft being made, the solar tracking control system implemented in the microcontroller will execute a function with 8535 flowchart as shown in Figure 2 (Jaya & Darlis, 2012; Kuswadi, 2007; Rifqi & Darlis, 2013; Udayana & Darlis, 2014).

The output voltage of four sensors, solar cells transformed by the ADC and read by the FPGA, then determined the value where the biggest and made the value of reference. Of the value of the reference later when reading the value of the largest cell1 then it will be compared to cell2. If the cell1 value is greater than the value of cell2 then motor X will move to the left assuming speed is already regulated by fuzzy logic controller and vice versa. Similarly, if the largest cell2 then logically the same as the logic of the largest cell1. This applies also to the cell3 and cell4.

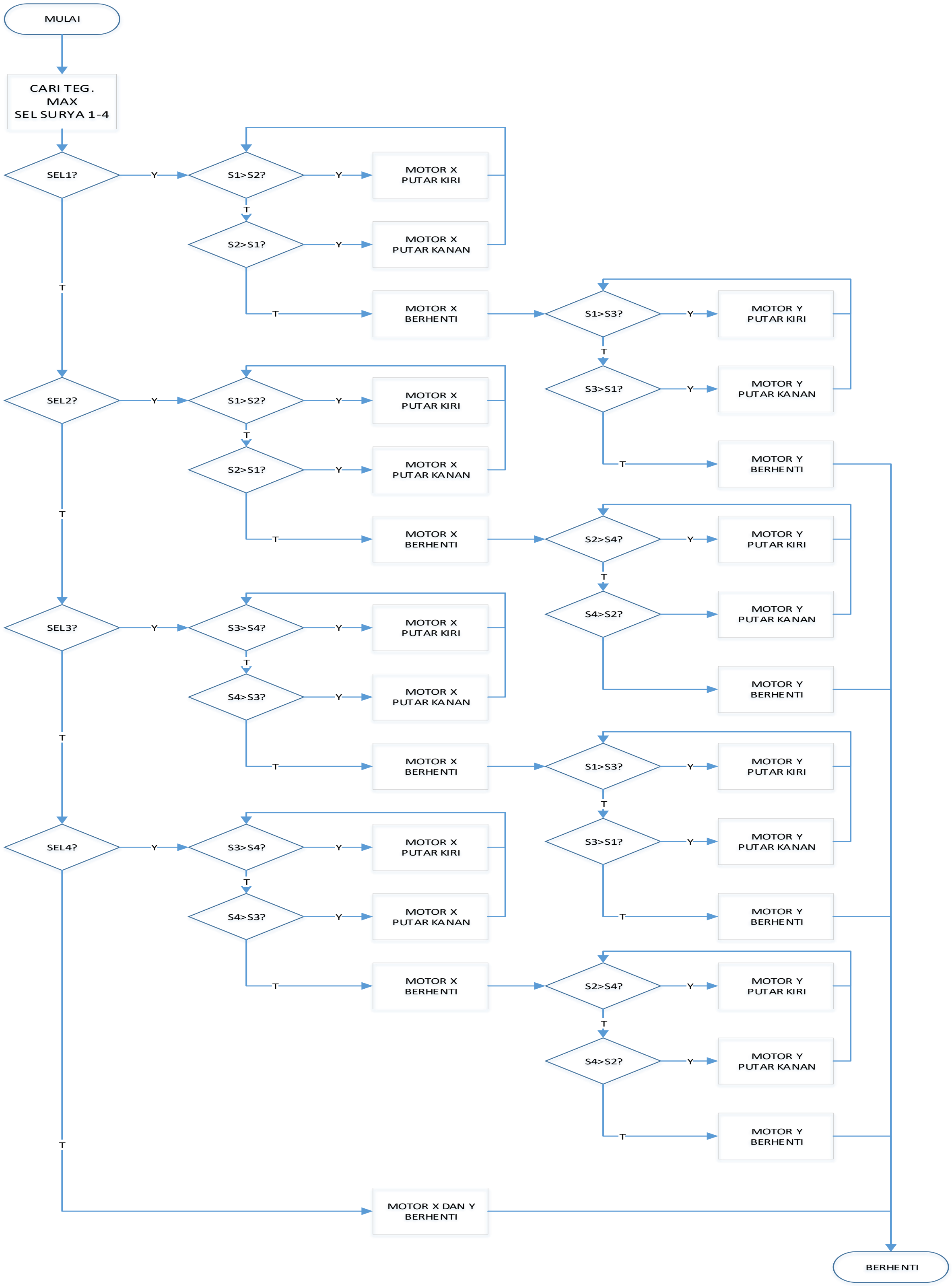

Figure 2. Sun Tracker System Flowchart

Then when the value of the cell1 = cell2 or cell3 = cell4 then the X motor stops and then FPGA compare again the value of the cell located at the diagonal position. If the cell1 value is greater than the value of cell3 then motor Y moves to the left and if otherwise then motor Y will move to the right. Similarly, if the cell2 value is greater than the value of cell4 then motor Y will move to the left and vice versa. If the value of a cell that is diagonally position already equal then the Y motor will stop.

Mechanical chassis model for solar Tracker System on research is designed using Autodesk Inventor® software as indicated by 3D simulation in Figure 3.

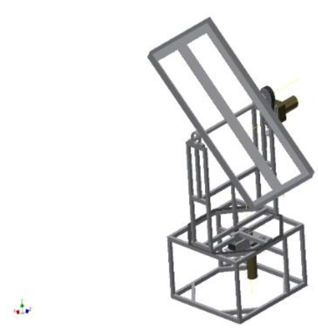

Figure 3. 3D simulation framework of the solar Tracker systems and solar panels on Autodesk Inventor®

DC X motor position is placed at the bottom of the main frame of the solar panel to organize the movement in the X axis and the Y DC motor is placed in the central part of the main frame of the solar panel to organize the movement in y-axis. Order implemented using aluminum materials.

The process of fuzzy logic that is coded in the FPGA must have functions that are generally shown in Figure 4. To ensure the process of fuzzy logic in accordance with the draft being made, then the initial simulation using MATLAB® program with Fuzzy Logic Toolbox.

Figure 4. Fuzzy logic Flow diagrams

After getting the value of the voltage of the solar cells, the next step is the fuzzification that is the process of modifying the data value of each sensor into the set of fuzzy membership functions according to the as shown in Figure 5 for the solar cells 1 and 4 as well as in Figure 6 for solar cells 2 and 3

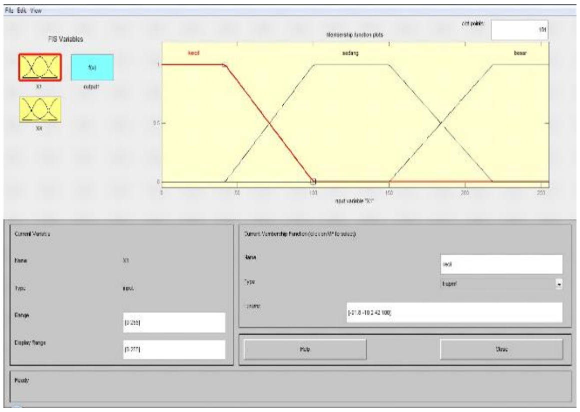

Figure 5. Functions of Linguistic output of solar cells X 1 and X 4

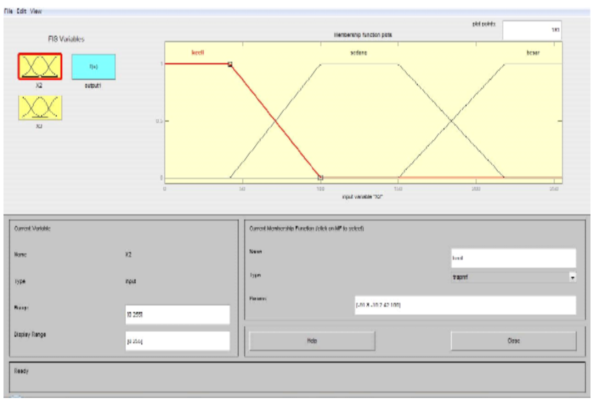

Figure 6. Functions of Linguistic output of solar cells X2 dan X3

After a fuzzification, then the next stage of the making of the fuzzy rules to determine the output based on the input from the f. The rule base contains the fuzzy rules used to control the system. These rules are created based on logic and human intuition, as well as closely related to the way the thoughts and personal experiences that make it. So it is not wrong if it is said that these rules are subjective, depending on the acuity that makes. The rule set is used to connect between input variables and output variables.

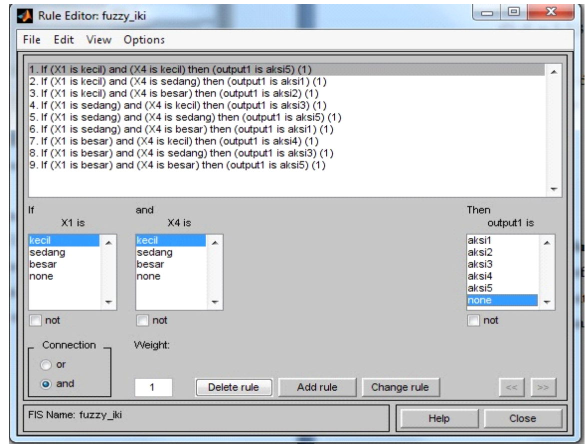

Figure 7. Toolbox Rules

The process of defuzzification using method of weighted average, i.e. taking the average value by using a weighting of fuzzy sets in the form of degrees of membership. The output of defuzzification simulation using MATLAB shown in Figure 8.

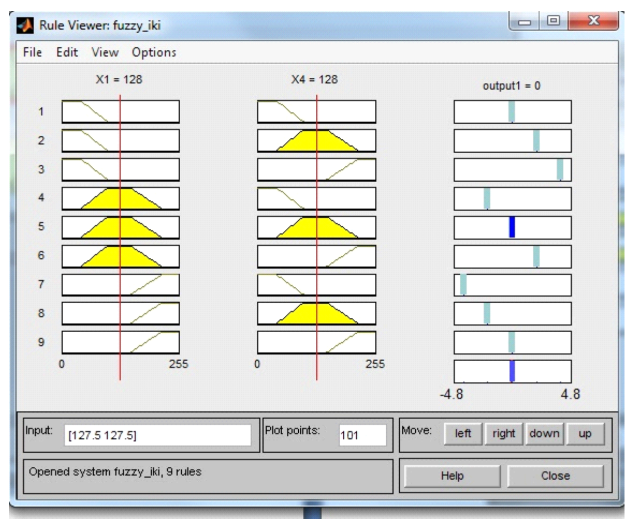

Figure 8. Result of Defuzzification System

After the simulated in MATLAB, rule fuzzification and defuzzification logic is encoded using the VHDL code and implemented for FPGA XC3S200A on board the XuLA-200.

RESULTS AND DISCUSSION

The average total energy produced solar panels that use solar trackers for 10 days is 716058.87 Joule. DC motor energy used to perform tracking was 950.4 joules. Meanwhile, the energy load of the system for 1 hour was 8,208 joules. Then the energy of the system load averages for 11 hours is 90,288 joules. So the total energy produced solar panels that use solar trackers are produced of 624820.47 joules. The graph of energy produced can be seen on the figure 9

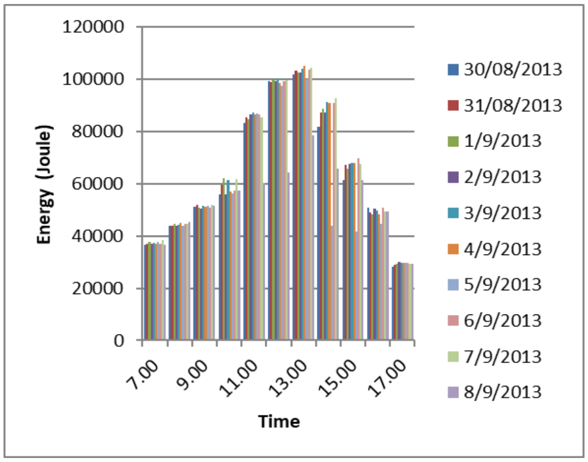

Figure 9. The graph of energy generated in the solar panels which use solar trackers

Testing angle sunlight is implemented as shown in the illustration in Figure 10. From the figure 10 it can be seen that the movement on the X axis and Y axis are set to follow the movement of the direction of rotation counterclockwise parallel axis East-West and North-South facing

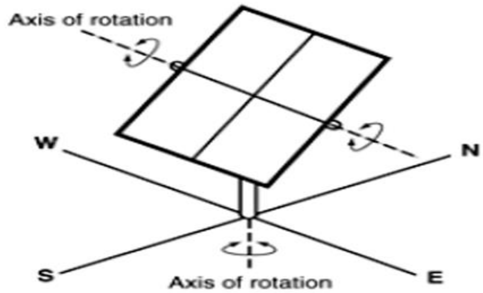

Figure 10. Illustration of movement on X and Y axis

The results of measurements of the average - angle on the Y axis can be seen on the table 1.

Table 1. The results of measurements of the - average angle on the Y axis

Time	The angle on the Y axis (°)
07.00	22
08.00	38.5
09.00	54
10.00	68.5
11.00	79.5
12.00	90
13.00	101
14.00	112.5
15.00	124.5
16.00	140.5
17.00	161.5

From the movement on the solar trackers made it brings that movement on the X axis only happens 1 time when first solar Tracker determines to detect sunlight i.e. at 7. While on the Y axis is always changing. This happens because Indonesia is a country located on the equator, it is therefore the position of the Sun would not be far away in the North or the South. It was the cause why the movement of the X axis does not occur significantly and only the Y axis changing over time.

CONCLUSION

The energy generated by solar panels that use Sun Sights greater than solar panels placed in stationary. The accuracy of tracking the Sun using FPGA better than using other systems.

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